CHANGES IN THE ELASTICITY OF DEMAND FOR FRESH CHOICE BEEF, 1950-1978

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Abstract. This study used least squares regression techniques to estimate the demand for fresh choice beef in the U.S., 1950-1978. From the demand equation, estimates of price, income and cross elasticity of demand were derived. An objective was to determine if elasticity of demand has been decreasing. Problems with pooling of data, serial correlation and multicollinearity were dealt with. Estimated price elasticity of demand was found to be -.62. When this figure was compared to results of other studies (with the consideration that different estimating techniques and time periods were used) it was judged that elasticity of demand for fresh choice beef in the U.S. probably had declined between 1950 and 1978.

INTRODUCTION

It has been suggested that the price elasticity of demand for beef at retail is becoming more inelastic (Breimyer, 1961). However, in comparing various estimates of elasticity between time periods, definite conclusions are difficult to arrive at because of various factors which influence the magnitude of these estimates (Tomek, 1965). Model specifications as well as statistical procedures differ between studies.

The obvious solution to this problem is to use a single estimation technique over several time periods. However, limited sample data for relatively short time periods can also lead to questions regarding reliability. The approach taken in this study was to estimate elasticity coefficients over a long term period (1950-1978) with the hypothesis that the elasticity of demand so derived would be more inelastic than estimates from previous studies. In effect, it was hypothesized that the more inelastic responses from the latter part of the time period would lower the estimate for the entire period when compared to estimates from previous studies.

The objectives of this study were to estimate the U.S. retail demand for fresh choice beef sold in retail stores for the years 1950-1978, to estimate the price, income and cross elasticities of demand and to determine if the elasticity of demand had decreased during the time period studied.

PROCEDURES

The original specification of the model involved a single equation expressed in arithmetic form. The dependent variable was per capita beef consumption. The independent variables were deflated retail prices of beef, pork, lamb, ready-to-cook fryers and per capita personal income. These variables were chosen based on conventional economic theory and on previous empirical studies. Quarterly data were fitted to the equation by ordinary least squares. The general linear models (GLM) procedure of the Statistical Analysis System (SAS) was used (Barr, *et al*).

The statistical results from this model, however, were not satisfactory. The Durbin-Watson statistic indicated serial correlation and a regression of the independent variables on each other indicated that multicollinearity was a problem. Generalized least squares procedures were used in an attempt to overcome these problems, but the model as originally specified also was judged inappropriate.

After a thorough review of the results of the original model along with the various tests of reliability, the variables retail lamb and ready-to-cook fryer prices were removed from the equation. In effect, it was judged that these variables had no measurable effect on consumption of beef. The resulting model was:

$$Q_{bt} = B_o + B_1P_{bt} + B_2P_{pt} + B_3Y_t + V + u \quad (1)$$

where:

Q_{bt} = quarterly per capita beef consumption expressed on a retail weight basis.[1]

B_o = intercept

B_1, B_2 and B_3 = parameters to be estimated

P_{bt} = Composite by quarter (simple monthly average) of the retail price of U.S. choice beef, deflated by the C.P.I. and stated in cents per pound.[2]

P_{pt} = Composite by quarter (simple monthly average) of the retail price of pork, all grades, deflated by the C.P.I. and stated in cents per pound.[3]

Y_t = Quarterly per capita disposable income, deflated by the C.P.I.[4]

V = Dummy variable adjusting for seasonal variation by quarter.[5]

t = Current time period.

u = Error term

This model assumes the slope and intercept remain constant over the entire time period. To justify the use of such a model for estimation of elasticity of demand, it is necessary to test that assumption. This test involved the specifications of three additional models.[6]

The data were divided into two time periods: 1950-1973 and 1974-1978. This division was subjective in that the latter period was of primary interest. The second model held the slope constant but

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[1]This was expressed in retail weight equivalents. In some years this was available only on a carcass weight basis. In these instances the data were converted to a retail weight basis with a factor of 1.4:1 (1.4 pounds carcass weight equals 1 pound retail weight). Beef Consumption Source: Livestock and Meat Situation (Aug. 17, 1956); Food Consumption, Prices, Expenditures (1968 Supplements for 1975); Livestock and Meat Situation (Dec. 1977).

[2]Beef and Pork Price Sources: Livestock and Meat Statistics (1973 and Supplement for 1977) and Livestock and Meat Situation (Dec. 1979).

[3]Ibid.

[4]Income Data Sources: Business Conditions Digest, p. 109; Agricultural Outlook, July 1976, Jan.-Feb. 1978, and April 1979.

[5]An explanation of this dummy variable technique can be found in Kuehn and Harner.

[6]A detailed explanation can be found in Pindyck and Robinfield. p. 80-81.

allowed the intercept to change. The null hypothesis was that the b-value of the dummy variable associated with intercept changes would not be significantly different than zero:

$$Q_b = B_o + B_1P_{bt} + B_2P_{pt} + B_3Y_t + B_4D_t + V + u \quad (2)$$

where D = a dummy variable equalling zero for 1950-1973 and one for 1974-1978.

The third model held the intercept constant but allowed the slope to change. The null hypothesis was that the b-value of the dummy variable accounting for slope changes would not be significantly different from zero:

$$Q_b = B_o + B_1P_{bt} + B_2P_{pt} + B_3Y_t + B_5(D_tP_{bt}) + V + u \quad (3)$$

where D_tP_{bt} = a continuous variable allowing the retail price of beef to vary with time.

The fourth model allowed both the slope and the intercept to change:

$$Q_b = B_o + B_1P_{bt} + B_2P_{pt} + B_3Y_t + B_4D_t + B_5(D_tP_{bt}) + V + u \quad (4)$$

All models were run and the following results were obtained:

1. In model (2), the null hypothesis was not rejected: The intercept variable coefficient was not significantly different from zero.
2. In Model (3), the null hyphothesis was not rejected: The slope variable coefficient was not significantly different from zero.
3. In Model (4), neither the slope variable coefficient nor the intercept variable coefficient was significantly different from zero.
4. Based on these results, it was judged that Model (1) would be useful for estimating elasticity of demand for beef.[7]

RESULTS

The regression results (ordinary least squares) are presented in Table 1. The same tests were performed on this equation as were mentioned previously. It was found that serial correlation still existed but based on evaluation of the statistical results and on the use of generalized least squares (the SAS Autoregression Procedure), it was judged that estimates would not be severely affected if levels of significance were at or better than 0.01. Estimation problems due to multicollinearity were effectively eliminated.

There was a strong inverse relationship between price and quantity of beef consumed. The pork price coefficient was not found to be significantly different from zero indicating questions as to the substitutability of pork for beef. The relatively high R^2 value indicated the level of explanation of the dependent variable by the independent variables included in the equation. The fact that 96 percent of the variation was explained by the independent variables indicated that lamb and fryers (previously eliminated from the equation) were not important variables explaining beef consumption.

Price elasticity of demand was –.627 at the arithmetic mean. Income elasticity was .807 and the cross-elasticity (pork prices and beef consumption) was .06.

Table 1
Regression Results for Model (1) 1950-1978

Variable	Mean Value	b-Value	Standard Error	Prob>t
Intercept B_o		13.6304	.8254	0.0001
Retail Beef Price P_{bt}	.8909	–12.7283	.7587	0.0001
Retail Pork Price P_{pt}	.6987	1.5969	.8631	0.0670
Personal Income Per Capita Y_t	2544.	.00575	.0001	0.0001
Quarter 1 V Q_1		–.0458	.1674	0.7847
Quarter 2 V Q_2		–.1592	.1659	0.3393
Quarter 3 V Q_3		.5234	.1673	0.0023

N = 116	F-Value = 523.89	Probability of greater F = 0.0001
DF = 115	R^2 = 0.9665	Durbin Watson Statistic = 0.66

The mean value for per capita beef consumption was 18.12 pounds

Table 2
Selected Price Elasticities of Demand at Retail for Beef

Source	Time Period	Estimation Method[a]	Elasticity
Nordkin, Judge and Wahbly	1921-41	ILS	–0.77
		OLS	– .96
Fox	1922-41	OLS	– .94[c]
Wallace and Judge	1925-55	LISE	–1.36
		TSLE	– .77
		OLS	– .76
Maki	6/1947-12/56	OLS	– .85[d]
Logan and Boles	1/1948-12/59	OLS[b]	– .65
Breimyer	1948-60	OLS	– .65[c]
Waugh	1948-62	OLS	– .69[c]
Tomek	4/1949-3/56	OLS[b]	–1.00
	4/1956-3/64	OLS[b]	– .90
George and King	1946-67	e	– .64
Langemeier and Thompson	1947-62	TSLS	– .95

a—ILS = indirect least squares; LISE = limited in formation maximum likelihood; TSLS = two stage least squares; OLS = ordinary least squares.

b—Elasticity derived from several OLS equations to take account of cross effects.

c—Elasticity computed as reciprocal of flexibility in price—dependent equation.

d—Direct Estimate from quantity—dependent equation

e—Variety of devices employed. (Some Statistical, Some Inferred from economic theory)

Source: A Survey of Agricultural Economics Literature. Vol. 2 Traditional Fields of Agricultural Economics. Lee R. Martin, ed. University of Minnesota Press, 1977. See p. 336 and References, pp 392-409, for authors respective work.

[7]It should be noted that if the null hypothesis for model (2) was rejected while the null hypothesis for model (3) was not rejected, for example, then model (2) would be used for estimating elasticity. Conversely, if the null hypothesis for model (3) was rejected, while the null hypothesis for model (2) was not rejected then model (3) would be used. If both null hypotheses were rejected, then the use of model (4) would be appropriate.

CONCLUSIONS

The relatively low elasticity of demand when associated with increasing levels of per capita consumption of beef imply that beef is being incorporated as a more necessary portion of the food budget even in the face of increasing prices. In fact, the income elasticity estimate of .80 suggests that beef consumption is affected more by real income changes than by changes in retail prices. Additionally, the lack of a significant relationship between pork prices and beef consumption further verifies an inelastic demand for beef.

Table 2 summarizes some of the results of other studies which estimated price elasticity of demand for beef. However, due to differences in estimation techniques, model specifications and time periods, it would be scientifically incorrect to make direct comparisons. A simple overview of the estimates in Table 2 compared to those of this study would indicate, however, that elasticity of demand for beef has been decreasing. This is especially so if the comparison emphasizes differences between time periods.

If this conclusion was deemed to be scientifically valid, it would be inferred that a major change has taken place since World War II on consumers' attitudes towards beef. A valuable future study would be one which evaluates the "modern" demand for beef in the United States.

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